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EVALUATION OF A K–5 MATHEMATICS PROGRAM WHICH INTEGRATES CHILDREN'S LITERATURE: CLASSROOM ENVIRONMENT AND ATTITUDES

ABSTRACT. This article describes a one-year study of 120 fifth grade students whose teachers participated in a program entitled Project SMILE (**S**cience and **M**athematics **I**ntegrated with **L**iterary **E**xperiences). The purpose of the study was to determine the extent to which the classroom implementation of Project SMILE positively influenced the classroom environment and student attitudes toward reading, writing and mathematics. This was accomplished by, first, facilitating a series of professional development workshops with the teachers and, subsequently, asking these teachers to use the strategies with their students in their elementary school classrooms. The research represents one of the relatively few studies that have employed learning environment dimensions as criteria of effectiveness in the evaluation of educational innovations. Methodologically, our study supported previous research that successfully combined qualitative and quantitative methods of data collection. The learning environment and attitude scales exhibited satisfactory internal consistency reliability and discriminant validity and, additionally, the actual form of most learning environment scales was capable of differentiating between the perceptions of students in different classrooms. The implementation of SMILE was found to have a positive impact on the students of the teachers who participated in the inservice program in that students' attitudes to mathematics and reading improved and there was congruence between students' actual and preferred classroom environment on the scales of satisfaction and difficulty. As well, prior research was replicated in that students' satisfaction was greater in classrooms with a more positive learning environment, especially in terms of student cohesiveness. Finally, qualitative data-gathering methods were used to construct a case study of the mathematics classes of a teacher who attended the SMILE professional development. This case study supported and illuminated the results from the questionnaire survey concerning the effectiveness of Project SMILE in terms of student attitudes and classroom environment.

KEY WORDS: attitudes, classroom environment, mathematics education, program evaluation, Project SMILE

In mathematics education, what to teach and effective ways to teach the content have become more publicly and hotly debated in recent years (Kennedy & Tipps, 2000). The demands of the new century require that all children acquire an understanding of mathematical concepts, proficiency in mathematical skills, and a positive attitude toward mathematics. According to the traditional view, students acquire mathematical skills by imitating demonstrations by the teacher and in the textbook (Battista, 1999). As

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today's students learn mathematics skills and concepts, they must apply, adapt, and extend old concepts to new tasks and existing ideas into new ideas (Kennedy & Tipps, 2000).

The National Council of Teachers of Mathematics (NCTM) took a decisive step toward improving the teaching of mathematics with the publication *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989). This work represented a major effort to create a set of standards to guide the revision of the school mathematics curriculum and its associated evaluation. The national standards are the basis for the district and state curricula in Miami-Dade County, Florida, where our research was carried out. Each mathematics lesson plan must reflect the district standards which are, in essence, the national standards.

The Basics of School Improvement and Accountability in Florida GE356 (FDOE, 1997) changed the way in which mathematics is taught in the state of Florida. The change focused on a shift from rote acquisition of information to the understanding of underlying mathematical concepts. Mathematical ideas can be developed together through reading, writing, listening and discussing mathematics (Santa, 1996). To accomplish the goal of increasing students' mathematical learning, school districts investigated a variety of instructional programs. Project CRISS (**C**reating **I**ndependence through **S**tudent-owned **S**trategies), which began as a local experiment in Montana, is now being implemented in 43 US states and three countries. The program was nationally validated in 1985. In 1993, the validation expanded to include Grades 4–12. The National Diffusion Network (NDN) provided funding for CRISS from 1985 to 1996, when NDN funding was eliminated by Congress (Santa, 1996). The NDN, part of the US Office of Educational Research and Improvement, provided validated projects with grant support for dissemination.

A basic underlying assumption of the project is that poor student performance is due to the students' inability to read content area texts (Santa, 1996). CRISS strategies were designed to develop thoughtful and independent readers and learners. Project CRISS focuses on teaching secondary students how to learn content area subjects (mathematics, science and social studies) through reading, writing, speaking and listening. Its initial evaluation showed that students learned how to apply the CRISS principles to all subject areas (Santa, 1996).

Project CRISS was adopted in Miami-Dade County at the beginning of the 1997–1998 school year. Because Project CRISS had already proven successful with secondary students, it was adapted for the elementary-school level and renamed **S**cience and **M**athematics **I**ntegrated with **L**iteracy **E**xperiences (SMILE). The purpose of our study was to evaluate

SMILE in terms of whether it positively influenced the classroom environment and student attitudes at the elementary school (K–5) level. This was accomplished by, firstly, facilitating a series of five professional development workshops with the teachers and, subsequently, asking these teachers to use the strategies with their students in their elementary school classrooms.

This research was significant in several ways. Little research had been done on the strengths and weaknesses of the integration of mathematics and children's literature. Secondly, it was important to investigate if SMILE might prove successful with elementary school students, just as Project CRISS had been shown to be effective with secondary students.

The evaluation included two types of variables, namely, attitudes and classroom environment. Our research involved the subject of mathematics, which has been the focus for relatively few past classroom environment studies (Goh, Young & Fraser, 1995; Majeed, Fraser & Aldridge, 2003; Spinner & Fraser, in press). The research represents one of a limited number of studies that have employed learning environment dimensions as criteria of effectiveness in the evaluation of educational innovations (Maor & Fraser, 1996).

BACKGROUND

Adaptation of CRISS

In 1998, the educational specialists in Miami-Dade County Public Schools assigned to the mathematics and science department were part of an intensive inservice training program for Project CRISS. These specialists were then able to begin training classroom teachers in the principles and strategies of Project CRISS. We felt that these principles and strategies would be of as much value to elementary (K–5) teachers as they are to secondary teachers. Research shows that exemplary teachers utilize strategies which encourage students to participate actively in learning activities (Fraser & Tobin, 1991, p. 287). Because historically educational specialists teaching elementary school mathematics use a hands-on, conceptual approach, the principles and strategies of CRISS seemed a perfect match for the elementary school setting. As a result, we were inspired to adapt the program for elementary (K–5) teachers and to rewrite many of the activities presented in the CRISS Manual using popular children's literature. It was our hope that, after teachers used the CRISS strategies incorporating hands-on activities in their teaching, students would be better able to conceptualize mathematics.

In 1999, we began adapting the CRISS materials for the elementary school and renamed the project SMILE (**S**cience and **M**athematics **I**ntegrated with **L**iterary **E**xperiences). SMILE focuses on teaching students reading, writing and mathematics through an integrated literature and activity-based (hands-on) mathematics program. Given the success of CRISS and the potential of SMILE, it was important to undertake this evaluation of its effectiveness.

The SMILE teachers' manual was designed to infuse the principles and strategies of CRISS and the national mathematics standards into each lesson plan. The SMILE manual consists of five thematic units which are presented to teachers during a five-day training session. Each unit focuses on one or more of the following foundational ideas in the NCTM standards: Number Sense and Operations, Measurement, Geometry, Data Analysis and Algebraic Thinking. Each unit spirals into the next and each contains built-in reviews and extension activities.

The first unit is entitled *The Greedy Triangle Meets the Attribute Block*. Organizational tools, including Venn diagrams, and critical thinking activities are infused into the objectives identified in the NCTM geometry content strand. Marilyn Burns' *The Greedy Triangle* serves as the literary context for children to learn how to differentiate between the attributes of geometric shapes. Students investigate what happens to a geometric shape when sides and angles are added to a polygon. Attribute blocks are used to illustrate the concepts.

The second unit, *Structures in Math, Science and Architecture*, addresses the NCTM content strand of Number Sense and Operations. The underlying concepts behind computation are taught through the use of linking cubes, color tiles and base-ten blocks. The students learn that each operational symbol has meaning. For example, the symbol for addition is the plus sign, which can represent the word 'combine' among other meanings. All four basic mathematical operations are discussed and conceptualized in this same manner.

The content strand of geometry is taught using *The Greedy Triangle*. In the story, the character of *The Greedy Triangle* adds one more side and one more angle each time until it becomes unhappy. Using eight basic two-dimensional polygons, the teachers investigate this principle by constructing geometric figures with straws. The culminating activity is the construction of a three-dimensional dodecahedron from 12 two-dimensional pentagons.

The third unit, *Rainbows and Fish*, draws on the book *The Rainbow Fish* by Marcus Phister. This unit focuses on the NCTM content strand of Number Sense and Operations. Addition and subtraction of fractions

are taught using the strategy of *cross multiplication*. Children learn least common multiple, greatest common factor and fraction reduction using an Asian strategy called the *ski-slope method*. Children explore geometric transformations by making a fish out of crackers. Students review Venn diagrams by discussing the attributes of *The Rainbow Fish* and *The Greedy Triangle* characters.

Bug Out on Math and Science, the fourth unit, deals with the NCTM content strands of Geometry, Data Analysis and Measurement. The focus of the unit is identifying angles, two- and three-dimensional objects, analyzing and collecting data, estimation and elapsed time. Students learn statistical vocabulary such as 'mean,' 'median' and 'mode' through a trivia game. *The Hungry Caterpillar* and *The Grouchy Lady Bug*, both by Eric Carle, serve as the children's literature connections. These activities incorporate calculators to illustrate their importance in critical thinking.

The final unit in the SMILE manual incorporates all previously-used CRISS principles and strategies as well as the NCTM content strands of Number Sense and Operations, Measurement, Geometry, Data Analysis and Algebraic Thinking. The teachers learn how to take any children's literature book and infuse all the principles and strategies of SMILE/CRISS. This final unit, *Math and Science for Chocolate Lovers*, addresses algebraic thinking using patterns of Hershey 'Kisses,' single and double bar graphs using Hershey Miniatures, and probability and statistics using M & Ms. The book, *Chocolate by Hershey* by Betty Burford, provides the literature connection for the unit. This biography of Milton S. Hershey is also used to teach the importance of mathematics vocabulary.

Field of Classroom Environment

Our study drew on the field of classroom environment research (Fraser, 1994, 1998a; Fraser & Walberg, 1991; Goh & Khine, 2002; Khine & Fisher, 2003). Also our research into learning environments is consistent with a long-standing tradition in this field of obtaining quantitative information through the administration of established questionnaires which assess students' perceptions of their classroom learning environment (Fraser, 1998b). Following recommendations made by Tobin and Fraser (1998), we also collected qualitative information based on observations and interviews and the interpretive techniques suggested by Erickson (1998).

One potentially useful application of classroom environment assessments which has been taken up surprisingly seldom in past research involves using classroom environment dimensions as dependent variables in evaluating educational innovations (see Dryden & Fraser, 1998; Maor & Fraser, 1996; Nix, Ledbetter & Fraser, 2004). Our study is notewor-

thy because it used classroom environment variables as process criteria of effectiveness in evaluating Project SMILE. Also, we followed the research tradition of investigating associations between student-perceived classroom environments and students' achievement and attitudinal outcomes (Fraser, 1994; McRobbie & Fraser, 1993).

This study also is distinctive in that it adds to the small number of recent learning environment studies (e.g., Goh, Young & Fraser, 1995; Majeed, Fraser & Aldridge, 2003; Spinner & Fraser, in press) that focused on the school subject of mathematics.

THE STUDY

Stages of the Study

Our study consisted of four stages. During *Stage 1 – Attitude Pretesting*, an attitude questionnaire, based on the 1988 NAEP (National Assessment of Educational Progress) survey, was administered to all students and teachers in the sample as a pretest. Also 10% of the students and teachers were interviewed regarding their responses to the attitude survey.

Stage 2 – Professional Development involved SMILE inservice courses for the designated teachers. These inservice courses were for five full days during a 10-week period. At the conclusion of each inservice day, the participants were asked to implement the lessons and materials with their students in their elementary schools and to return with student work samples the following time.

Stage 3 – Assessment of Actual and Preferred Classroom Environment. The students of the inservice teachers responded to a classroom environment survey as a pretest after the first day of the teachers' professional development activities. The *My Class Inventory* (MCI) (Fisher & Fraser, 1981; Fraser, 1989; Fraser & O'Brien, 1985) was chosen for several reasons. The reliability of the MCI had been established in previous research (Fraser & O'Brien, 1985; Goh et al., 1995; Majeed et al., 2003). The MCI assesses five classroom environment dimensions (Satisfaction, Friction, Competitiveness, Difficulty, and Cohesiveness) that seemed relevant to our study. The MCI has a simple two-point response format (Yes and No), which is suited to younger respondents, and it is easy to administer. Importantly, the readability of the questions allows them to be understood by students with only basic reading abilities. Because data collected during the 1997–1998 school year revealed that 58% of the students in M-DCPS were language deficient in that English is not their home language (*MDCPS Statistical Abstract 1997–1998*), we felt that the vocab-

ulary in the MCI and the NAEP attitude survey were appropriate for the sample of students. Ten percent of students responding to the MCI were interviewed about their responses.

In *Stage 4 – Attitude Posttest*, the attitude survey was readministered to the teachers and students in the sample at the completion of the professional development program. The mandatory teacher evaluations used by Miami-Dade County's Teacher Education Center and Project CRISS were also administered to the teachers and used as qualitative data.

The Sample

The sample covered mathematics classes at the elementary school (K–5) level. The teachers and students were selected to represent the diverse group of teachers and students found in the Miami-Dade County Public Schools, Florida, USA. The teachers, designated by the school principal to attend the SMILE workshop, were asked to participate in the research. Preference was given to teachers who teach Grade 5. A sample of 6 teachers from two schools was involved. With each teacher having over 30 students in his/her class, the sample size approached 200 students. After all results were collated, however, there were only 120 students who had completed all surveys, inventories and achievement tests, and this reduced sample without any missing data was used for statistical analyses. Six classrooms of Grade 5 students participated in the SMILE pilot study. These teachers and classes were from two schools that we call Tulip and Daniel Elementary Schools for the purposes of this article.

Tulip Elementary School is in a lower-income, African-American neighborhood. Ninety-eight percent of the students in this school receive free lunch (OEEMA, 2000) which the Federal government provides for students from low-income households. Tulip received a 'D' in Florida's school achievement-testing program (FDOE, 1997) and did not meet the passing criteria in reading or mathematics. The Principal allowed the use of the school as the site for the professional development workshops.

Daniel Elementary School is in a middle-class, multi-ethnic community. Two fifth grade mathematics teachers volunteered to be involved in the study. The Principal offered her school as a site for the professional development as well. This school received a 'C' in Florida's achievement testing program.

Instruments and Data Collection

A range of quantitative and qualitative data were collected relevant to this evaluation. Quantitative data were gathered from three sources. First, an adaptation of the 1988 NAEP (National Assessment of Educational

Progress) attitude inventory provided a measure of changes in student attitudes to reading, writing and mathematics. Second, Fisher and Fraser's (1981) My Class Inventory provided a measure of student perceptions of their classroom learning environment. Qualitative data were gathered from six classroom observations, student and teacher interviews that were recorded and transcribed, and student work samples that were collected by each teacher. We hypothesized that the program would promote improved attitudes toward the learning of mathematics and positive student perceptions of classroom environment. A particular focus was the effectiveness of the program across gender, ethnic backgrounds and socioeconomic levels.

An attitude questionnaire, based on the 1988 NAEP attitude survey, was administered to the six classes of fifth grade students. This survey dealt with student and teacher attitudes toward reading, writing and mathematics. The original NAEP survey was adapted for elementary students and validated by Dr. Okhee Lee of the University of Miami. The pretest and posttest attitude surveys were administered to both the teachers and students involved in the study. The teachers and students responded to the survey on the first day of the inservice workshop. The teachers responded to nearly the same survey as the students. For example, the students answered the question "Do you like mathematics?" whereas the teachers answered the question "Do you like TEACHING mathematics?"

We chose the My Class Inventory (MCI) as a measure of classroom environment (Fraser & Fisher, 1986). All of the students in the study completed the inventory. We chose this particular instrument because the vocabulary is well suited for the elementary school child, the responses are in a simple Yes–No format, and the answers are recorded on the questionnaire itself to avoid errors in transferring information from one place to another (Fraser, 1989).

The MCI is a one-page questionnaire that measures five dimensions, yet contains only 25 questions (Fraser, 1989). These dimensions are *Satisfaction, Friction*, *Competitiveness, Difficulty* and *Cohesiveness*. MCI scales can be used to measure student perceptions of *actual* or *preferred* classroom environment. The *preferred* form is concerned with goals and value orientations as it measures perceptions of the environment ideally liked or preferred. The *actual* form measures perceptions of the environment that currently exists in the classroom. Both forms were read aloud to the students in their own class setting. The reason for using both forms in our study was so that SMILE could be evaluated in terms of the degree of congruence between the actual and preferred classroom environment.

TABLE I

Internal consistency reliability (Cronbach alpha coefficient) and discriminant validity (correlation with other scales) for attitude scales for pretest and posttest

Attitude scale	No of items	Form	Alpha reliability	Correlation	
				Writing	Mathematics
Attitude to reading	4[a]	Pretest	0.64	0.00	0.74
		Posttest	0.60	−0.18	−0.14
Attitude to writing	5	Pretest	0.64		0.00
		Posttest	0.50		0.40
Attitude to mathematics	5	Pretest	0.51		
		Posttest	0.60		

The sample consisted of 120 students.
[a]Item 5 omitted.

RESULTS FROM QUANTITATIVE INVESTIGATION

Reliability and Validity of Attitude and Environment Scales

The first research question involved the reliability and validity of the attitude and learning environment scales when used with our sample of elementary mathematics students. The attitude instrument used in the present study consists of five items that assess each of Attitude to Reading, Attitude to Writing and Attitude to Mathematics. These items were based on a NAEP (1988) Attitude Survey. These 15 attitude items were administered both as a pretest and as a posttest to the sample of 120 elementary school students whose teachers were teaching the SMILE program.

Table I provides, for each attitude scale, an estimate of scale internal consistency (the extent to which items in the same scale measure a common construct) and discriminant validity (the extent to which a scale measures a unique dimension not assessed by another scale). Whereas internal consistency was assessed using Cronbach's alpha reliability coefficient, discriminant validity was assessed using the correlation of a scale with the other scales as a convenient index. Data were analyzed separately for pretest and posttest responses.

When Item 5 was omitted from the Attitude to Reading scale, the alpha reliability coefficient rose from 0.54 to 0.64 for the pretest and from 0.42 to 0.60 for the posttest (Table I). Although the reliability values in Table I are relatively low, they provide adequate support for the reliability of short attitude scales containing only four or five items each.

TABLE II

Internal consistency reliability (Cronbach alpha coefficient), discriminant validity (mean correlation with other scales) for actual and preferred forms, and ANOVA results for ability to differentiate between classrooms for each MCI scale

MCI scale	No of items	Form	Alpha reliability	Mean correlation	ANOVA eta^2
Satisfaction	5	Actual	0.67	0.28	0.15**
		Preferred	0.70	0.46	
Friction	5	Actual	0.68	0.20	0.12**
		Preferred	0.70	0.46	
Competitiveness	5	Actual	0.64	0.25	0.06
		Preferred	0.74	0.42	
Difficulty	4[a]	Actual	0.51	0.15	0.13**
		Preferred	0.51	0.06	
Cohesiveness	5	Actual	0.77	0.20	0.08*
		Preferred	0.89	0.47	

* $p < 0.05$.
** $p < 0.01$.
[a]One item was omitted from the Difficulty scale.
The eta^2 statistic is the ratio of 'between' to 'total' sums of squares and represents the proportion of variance in MCI scores accounted for by class membership.

Table I shows too that, for most cases, the correlation of an attitude scale with the other two attitude scales is relatively small with the exception of Attitude to Reading with Attitude to Mathematics. This suggests that the three attitude scales are relatively independent of each other.

In terms of the reliability and validity of the MCI (My Class Inventory), the same two indices of internal consistency and discriminant validity are reported in Table II separately for the actual and preferred forms for the sample of 120 students. Alpha coefficients range from 0.51 to 0.77 for the actual form and from 0.51 to 0.89 for the preferred form. As a convenient index of discriminant validity, use was made of the mean correlation of a scale with the other four MCI scales. Discriminant validity indexes range from 0.15 to 0.28 for the actual form and from 0.06 to 0.47 for the preferred form. Overall, the data in Table II suggests that both the actual and preferred forms of MCI scales display adequate internal consistency and discriminant validity.

The last column of figures in Table II provides evidence about whether the actual form of each MCI scale is capable of differentiating between the perceptions of students in different classes. Ideally, students within the same class should perceive its environment relatively similarly, whereas

TABLE III

Average item mean, average item standard deviation and difference between pretest and posttest scores (effect size and t test for paired samples) for attitude scales

Attitude scale	Average item mean		Average item standard deviation		Difference	
	Pre	Post	Pre	Post	Effect size	t
Attitude to reading	2.64	2.54	0.41	0.52	0.22	−1.69
Attitude to writing	2.52	2.75	0.48	0.33	0.57	5.34**
Attitude to mathematics	2.39	2.68	0.48	0.43	0.64	4.97**

$N = 120$ students.
** $p < 0.01$.

mean class perceptions should vary from class to class. This characteristic was explored for each MCI scale by performing a one-way ANOVA with class membership as the main effect. Table II shows that all scales except Competitiveness were able to differentiate between classes. The eta^2 statistic, which represents the proportion of variance in an MCI scale accounted for by class membership, ranges from 0.06 for Competitiveness to 0.15 for Satisfaction.

Changes in Student Attitudes

The second research question was: When teachers participate in the professional development activities for Project SMILE, are there changes in the attitudes of students regarding reading, writing and mathematics? Teachers attended a series of five professional development workshops lasting five full days during a ten-week period. After the first day of the workshop, one of the researchers went to each teacher's classroom and administered the attitude survey to the teacher's students. After the teachers completed the SMILE professional development course, the attitude questionnaire was re-administered as a posttest. Changes in student attitudes between the pretest and posttest were used in evaluating the effectiveness of the SMILE inservice program.

Table III shows the average item mean and average item standard deviation, as well as the effect size and the results of t test for paired samples for differences between pretest and posttest scores on each of the attitude scales with the individual student as the unit of analysis. The average item mean (i.e. the scale mean divided by the number of items in a scale) was

used to provide a meaningful basis for comparing the means of scales containing differing numbers of items.

Whereas the results of the t tests provide information about the statistical significance of pre-post difference, effect sizes were calculated as a measure of the magnitude (or educational significance) of the differences, as recommended by Thompson (1998). The effect size is simply the difference in means divided by the pooled standard deviation.

There were statistically significant differences ($p < 0.01$) between pretest and posttest in student attitudes toward both writing and mathematics (Table III). Attitude toward writing improved in its average item mean score from 2.52 to 2.75 (or an effect size of 0.57 standard deviations). The mean for attitude toward mathematics changed from 2.39 to 2.68 (an effect size of 0.64). Attitude toward reading did not show a statistically significant change between pretest and posttest. The effect sizes of over half a standard deviation for the two statistically significant changes suggest that the magnitudes of pre-post changes are educationally important.

Table III demonstrates that there was an improvement in attitudes to mathematics and writing between pretest to posttest, but a small and statistically nonsignificant decline in student attitudes toward reading between pretest and posttest. The positive change in student attitudes toward mathematics and writing after the implementation of SMILE was one of the goals for the program. Perhaps attitude toward reading did not change appreciably because SMILE concentrates on weaving writing and mathematics into the reading. The children might not have known that, in essence, they were learning reading skills at the same time they were learning mathematics. Overall, the results support the effectiveness of SMILE in promoting positive student attitudes.

Comparing Actual and Preferred Learning Environments

The third research question was: after the teachers participate in the professional development activities for Project SMILE, is there congruence between actual and preferred classroom learning environment? In contrast to the attitude questionnaire which was administered as both a pretest and a posttest, the MCI was administered on only one occasion. However, because it was administered in both an actual version and a preferred version, it still was possible to evaluate Project SMILE in terms of the degree of congruence between the actual environment present in these teachers' classrooms and that preferred by students.

Table IV reports the average item mean for the actual and preferred forms of each MCI scale, together with the average item standard deviation and the difference between actual and preferred scores on each scale

TABLE IV

Average item mean, average item standard deviation, and difference between actual and preferred scores (effect size and t test for paired samples) on each MCI scale

MCI scale	Average item mean		Average item standard deviation		Difference	
	Actual	Preferred	Actual	Preferred	Effect size	t
Satisfaction	2.66	2.67	0.30	0.15	0.24	0.11
Friction	2.43	2.19	0.28	0.26	0.89	−8.07**
Competitiveness	2.61	2.34	0.30	0.33	0.86	−8.08**
Difficulty	2.14	2.23	0.22	0.49	0.27	1.68
Cohesiveness	2.39	2.61	0.33	0.25	0.76	8.16**

$N = 120$ students.
** $p < 0.01$.

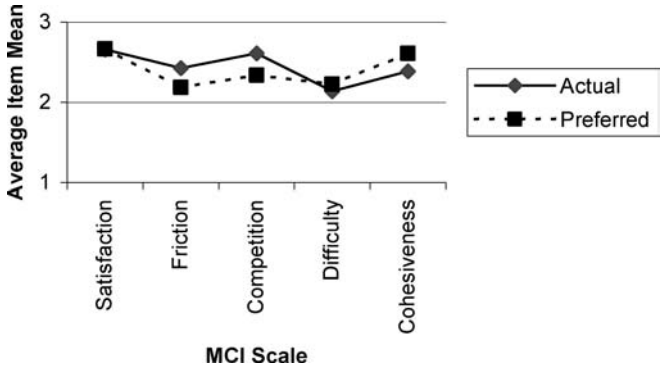

Figure 1. Average item mean for the actual and preferred forms of MCI.

(effect size and results of a t test for paired samples). Mean scores also are graphed in Figure 1.

Table IV shows that students prefer a significantly more favorable classroom environment on the three scales of Friction, Competitiveness and Cohesiveness. That is, students prefer less Friction, less Competitiveness and more Cohesiveness. Effect sizes exceed three quarters of a standard deviation for these three scales. For the other two MCI scales of Satisfaction and Difficulty, differences between actual and preferred scores were statistically nonsignificant. This pattern, in which students prefer a more positive learning environment than the one perceived to be actually present, replicates prior research in numerous countries (Fisher & Fraser, 1983; Fraser, 1998a).

In terms of evaluating the effectiveness of SMILE teachers in creating positive learning environments, it appears that the levels of classroom Satisfaction and the Difficulty of the work that are actually created by these teachers are very similar to the levels preferred by the students. These results provide some support for the effectiveness of SMILE.

However, relative to student preferences, the actual environment of the SMILE teachers' classrooms is perceived to have too much Friction and Competitiveness and too little Cohesiveness. These results provide some useful formative evaluative information about how to improve SMILE in-service programs by including an emphasis on the importance for teachers to increase cohesiveness and reduce friction and competition in their mathematics classrooms.

Associations between Attitudes and Learning Environment

The fourth research question involved relationships between students' perceptions of classroom environment and their attitudes. In past learning environment research, many studies have investigated associations between students' outcomes and the nature of the classroom environment (Fraser, 1994; McRobbie & Fraser, 1993). Our study followed this tradition by exploring associations between students' attitudinal outcomes (namely, Satisfaction from the MCI and the three scales assessing attitudes to reading, writing and mathematics) and students' perceptions on the other four learning environment scales of the MCI (Friction, Competitiveness, Difficulty and Cohesiveness). It should be noted that, for the purposes of these analyses, the Satisfaction scale from the MCI was conceptualized as an attitude outcome and used as a dependent variable as recommended by Majeed et al. (2003). The results are reported in Table V.

The simple correlation analysis provides information about the bivariate relationship between each attitude outcome and each classroom environment scale. The multiple correlation describes the joint relationship between each attitude outcome and the set of four classroom environment scales. The regression coefficient describes the association between an attitude scale and a particular environment scale when the other three environment scales are mutually controlled.

Table V shows that there are no statistically significant associations between classroom environment and attitudes to reading, writing or mathematics. However, student Satisfaction is statistically significantly correlated with all four learning environment scales. As well, the multiple correlation between Satisfaction and the set of environment scales is 0.53 and is statistically significant. The regression coefficients suggest that Cohesiveness is a significant independent predictor of student Satisfaction

TABLE V

Simple correlation and multiple regression analyses for associations between student attitudes and four MCI scales

MCI scale	Outcome-environment association							
	Satisfaction		Attitude to reading		Attitude to writing		Attitude to mathematics	
	r	β	r	β	r	β	r	β
Friction	−0.23*	−0.10	−0.15	−0.15	0.02	−0.15	−0.13	−0.02
Competitiveness	−0.21*	−0.06	0.01	0.11	0.07	0.01	0.10	0.01
Difficulty	−0.18*	−0.15	0.08	0.00	−0.05	0.06	0.04	−0.07
Cohesiveness	0.50**	0.44**	−0.00	−0.03	−0.08	−0.05	−0.01	−0.08
Multiple correlation (R)		0.53**		0.17		0.16		0.12

*$p < 0.05$.
**$p < 0.01$.
$N = 120$ students.

when the other environment scales are mutually controlled. Overall, the results in Table V suggest that student Satisfaction is higher in classes that have a more favorable classroom environment in terms of less Friction, less Competition and, especially, more Cohesiveness.

RESULTS FROM QUALITATIVE INVESTIGATION

Six students and six teachers were interviewed privately using the NAEP attitude survey as a basis for designing interview questions. The questions were read aloud and students' responses were recorded and transcribed. The teachers collected student work samples as proof that the teachers were implementing the program in their classrooms.

Findings based on qualitative information are summarized in the following sections using case study methods. In particular, the following case study describes one of the teachers, Mrs Tanya Robinette, and her student, Barbara. Tanya teaches at Daniel Elementary and Barbara is in her homeroom class. In the sections below, we use 'I' to refer to the first author of this paper.

Why Tanya Robinette Was Chosen

Upon the request of the Principal, I visited Daniel Elementary three times to help the teachers' textbook committee select a new mathematics textbook. Tanya was a member of the textbook adoption committee. After viewing the 13 state-adopted textbooks, the Principal, Tanya and I were convinced that the research-based textbook would be a suitable book to implement. After we finished writing SMILE, I asked Tanya if I could use the children in her classroom to try out some of my lessons. She agreed. She attended the first series of SMILE workshops.

Tanya Robinette teaches 5th grade mathematics at Daniel Elementary School located in a large, urban school district in the Southeast of the USA. The district has the highest percentage of Spanish and Haitian-Creole Limited English Proficient (LEP) students in the state. This is Tanya's 26th year of teaching. She has been at Daniel for her entire teaching career. For the past two years, the school used a research-based mathematics program from the University of Chicago. That is not the sole program that Tanya uses. Experience has taught her that there is good in any program. She finds new lessons and strategies and uses them when teaching children. She attends at least two mathematics workshops per school year. She says that she is always looking for "the program" to implement so that she won't have to write every lesson herself.

Tanya is not bilingual. When she began teaching at Daniel, this did not pose a problem, but now it is necessary for a translator to be present during parent conferences. Nearly half the parents do not speak English. She is also finding that children are bringing in other strategies for learning mathematics from their home countries. Tanya used to say: "My way is the right way and it's the only way." Now, she is learning other strategies to help her children.

I interviewed the teachers and students before and after the SMILE inservice program. I also modeled three lessons in each classroom. Each person was privately interviewed in the school setting. I took notes and tape-recorded each interview.

Tanya Talks about Her Class

Tanya neither likes to teach reading or writing nor feels that she is good at teaching reading and writing. She thinks that, if she tried, she could teach reading and writing well. But she has always loved teaching mathematics. She thinks that teaching writing is boring and difficult. When the Principal asked her if she would like to departmentalize the fifth grade, she was thrilled. The students have been departmentalized for the past three years.

She now teaches mathematics to one half of the students at Daniel and teaches lessons to the entire grade level once a week.

Tanya loves to teach mathematics and is good at teaching it. She believes that everyone can teach mathematics well if they try. Teaching mathematics is not boring or hard. She uses the required mathematics textbook as a reference. She is required to use the assessments from the research-based mathematics textbook. She said that it is difficult for some veteran teachers to use the new text, but she finds it challenging and fun to teach. She felt that this text exemplifies the way in which mathematics should be taught. She did caution that she did not teach the textbook page by page. She uses the textbook about half of the time. For the rest of the lessons, she teaches material from a variety of other good programs.

Tanya's classroom is aesthetically pleasing. She has mathematics-related bulletin boards, the manipulatives are easily accessible, children's work is displayed and the children are engaged in learning activities. The 42 desks are in straight rows. I suggested that Tanya move the children into groups. She declined at this point because she said that this was the beginning of the year and that all of the children did not have self-control. I observed Tanya teaching a lesson on the addition of fractions with unlike denominators. She demonstrated how to solve the algorithm procedurally. The children looked perplexed. Eleven of the children raised their hands for help. Using the blackboard, Tanya solved example after example in this same manner. When one child asked if there was another way to do the problem, Tanya responded: "No, this is the only way. You must learn it this way because it is on the test." After doing 20 examples at the board, she gave the children a written assignment. "Open your books on page 221 and do numbers 1 to 25." The children all opened their books. They all attempted to do the first problem. Some of the children attempted to complete the assignment, while others called "Mrs Robinette" over and over again to seek help. Tanya walked around helping individual students. Most of the children did not understand how to begin, much less complete, the assignment.

How I Met Barbara

On my first day of observing, Tanya introduced me to the class. She explained that we were doing research and that we would be observing and teaching the class throughout the semester. The minute that Tanya was finished introducing us, a girl ran up to us, gave us a big hug and said: "My name is Barbara and I hate mathematics." She also said that she was the only one in the class who had a 'D' grade. The teacher later verified that fact. Barbara walked back to her seat in the back of the room and

seemed to listen to Tanya attentively during the lesson. Upon receiving the assignment, Barbara immediately put her head down. I walked over to her and asked if I could help. She said: "I can't do this because I am the dumbest one in the class." At this point, I knew that Barbara would be the subject of a case study.

Barbara, a fifth grade student at Daniel Elementary School, was excited about being interviewed. At the onset of the interview, she again told me how much she hated mathematics and how dumb she was in mathematics. I started the interview. She told me that she loves to read. She reads approximately seven books per week. She loves to read any kind of book. She believes that everyone can read well if they try. Reading is never boring to her and she says that, if reading is boring to other children, it is because they just don't want to read. Reading is not hard for Barbara. She usually gets a 'B' grade. She said that she gets a 'B' and not an 'A' because she doesn't turn in her written assignments.

Barbara also likes to write. She once wrote a story about ketchup falling in love. She thinks that she is good at writing. She also thinks that everyone can write well if they try. Writing is not boring for her and it is not hard. For fun at home, she writes stories on the computer. Her mother gave her a book of story starters and she loves to write and illustrate the stories using her computer.

Barbara has never liked mathematics. Because it was early in the year, she was not sure if she liked mathematics in fifth grade or not. She said that she had to find out how the teacher was before she could make up her mind. She remembers when she first started hating mathematics. It was in first grade. She said that, because she did not know her addition and subtraction facts, she was put in the "dumb class." Ever since then, she has hated mathematics, especially computation. She thinks that she would like to do mathematics if she could relate it to things that she likes to do in real life – like shopping!

After this initial observation day, the SMILE workshops began with Tanya Robinette in attendance.

Working at Daniel Elementary School

All fifth grade students at Daniel Elementary School spent one hour per week in a whole-group lesson. These classes are held in the cafeteria. Tanya Robinette taught one new mathematics concept per week to 150 students. The children sat at cafeteria tables using only paper and pencil. Tanya taught the lesson using an overhead projector while the children took notes. Three teachers and three paraprofessionals (teacher aides) served as monitors to assist children. The children worked diligently throughout

the one-hour session. About every ten minutes, Tanya would choose a child to come to the overhead projector and explain an answer to the rest. When Tanya was asked who decided to have these sessions, she told me that the teachers decided to do it this way because all the children would then get the same instruction on the most difficult topics on the statewide achievement test. Because Tanya was the mathematics expert, she would teach the lessons and the other teachers would follow up. These classes were held weekly from the first week of school until the week before the administration of the statewide achievement test.

We were disturbed because, if these were the most important concepts on the statewide achievement test, why weren't they being taught using hands-on activities? We hoped that this would change after Tanya had completed the SMILE training.

Robinette's Concerns

After observing the group lesson, Tanya and I spoke privately. The use of manipulatives and children's literature are the main emphases of the SMILE workshops. Mrs Robinette expressed the desire to use manipulatives, but found that the children were too disruptive and out of control. This is also the reason why she had the children put their desks in straight rows. She was also afraid to use children's literature as an introduction to a mathematics lesson. She said that the children thought that these books are "baby books." We discussed this problem and I told her that, after I taught three lessons in her classroom, I hoped that she would feel confident enough to try to incorporate these activity-based strategies into her daily lesson plans.

The Lessons

The first lesson that I taught, Data Analysis for Chocolate Lovers, introduced the children to mean, median, mode, theoretical and actual probability, and the relationship between circle and bar graphs. I used M & Ms to help to illustrate the concepts. The first thing that I asked the children to do was to move their desks into groups of four. They were told that they must work with this group, and that there would be no exceptions. I gave the students markers, scissors and glue to use. The children seemed surprised that they would use these in mathematics class. I had to go over my rules for the use of these things.

I taught my lesson on the topic of mean, median and mode. I read the story, *Mrs Mean, the Math Teacher*, by Gretel Mink. This story was written by Gretel to help her to remember the definitions of mean, median and mode. After the story, the children played a chocolate trivia game. The

children read facts about chocolate. They were asked to estimate the answers, analyze the responses and find the mean, median and mode of their set of numbers. I discussed the estimates and I gave the correct answers for this chocolate trivia.

The children were then given a cup of M & Ms to count and to make a bar graph of the frequencies of the different M & M colors. The bar graph was then turned into a circle graph. I then began to discuss theoretical and actual probability. The children experimented with replacement probability using 10 M & Ms. The children recorded 100 trials of drawing the candy from a cup, recording the color and placing the candy back in the cup for the next draw. The results were recorded and conclusions were drawn. We discussed the findings. This lesson took two hours for the students to complete. There was not one discipline problem. When I administered a written assessment the following week, scores ranged from 92% to 100%.

I watched Barbara throughout the lesson. She seemed confident that she could complete the lesson. As I monitored the progress of the lesson, I kept our eyes on Barbara. She did not ask questions. Her group worked well together. She got 99% on her assessment. She brought her test to us to see.

Tanya's Perception

After watching me teach the first lesson, Tanya wanted to try to use manipulatives. She forced herself to use manipulatives to teach a lesson once a week. By the end of the year, she was using manipulatives at least two times per week. She had also been afraid to use a children's literature book as an introduction to a mathematics lesson. We introduced our third lesson with Eric Carle's *The Hungry Caterpillar*. Tanya saw how a primary (K–2) book could be used to teach higher-level mathematics. She saw how the children were engaged in the lesson. Not one child made 'a baby book' comment. She asked me to observe her teaching a lesson on the concept of elapsed time. She introduced the concept using Eric Carle's *The Grouchy Ladybug*. She said that she thought that the children would laugh at her when she read this book, but then she realized that the students would get to make their very own clock. We saw that they were actually learning something from 'the baby book.' Tanya was now ready to incorporate children's literature and manipulatives into every concept that she taught.

Barbara's Perspective

I taught three lessons to Barbara's class. At the end of a ten-week period of time, I asked Barbara the same questions about mathematics again. When I asked her if she liked mathematics, she said: "Yes, when we use the

mathematics books and activities that come after." When asked if she was good at mathematics, she said that, as long as she didn't have to do fast computation, she was pretty good. She was good at figuring out problems if she had to do so. She said that she could still see her first grade teacher yelling at her because she was dumb, but she knew now that she wasn't dumb in mathematics. Mathematics was no longer boring when I was there teaching a lesson. She said that her teacher was doing more and more fun things instead of lecturing. I asked if she was still getting a 'D' grade in mathematics and she said that she was now getting a 'B.' I followed Barbara's progress throughout the rest of the year. Her mathematics grades for each quarter of the year were 'D,' 'B,' 'B,' and 'A.' I visited Barbara during the last week of school. She came running up to me again and said: "Thank you for not letting me be dumb in mathematics. You know, I still remember the M & M mathematics. I think my favorite subject in high school will be statistics." We said to ourselves: "Success." For Tanya's students, the statewide achievement score was 'Level 4.'

Summary of Qualitative Research

I went back to Daniel at the end of the school year. The statewide achievement scores had just been announced. The school had gone from a 'C' to an 'A.' I asked Mrs Tanya Robinette the same questions that we had asked prior to the inservice program. She had a different attitude toward the teaching of reading and writing. She said that she would now like to teach reading and writing – but only through mathematics. She still thought that she would find it boring to teach reading and writing if she didn't integrate them into her mathematics, but that she would teach reading and writing if she was forced to do so. She said that, for next year, she would start using manipulatives for the group lessons. Her concern was that the fourth grade teachers didn't really concentrate on mathematics because the children were tested only in writing and reading. They really didn't do much mathematics until *after* the statewide testing was over at the end of March. She suggested to the Principal that all of the teachers take the SMILE inservice program during the next school year. When I asked her if she thought that the SMILE inservice program was the main factor in raising achievement test scores, she said that she thought that it was one of them. She said that SMILE, the new text, the group lessons and the departmentalization of the fifth grade all contributed to the achievement scores going up. She thought that the most significant changes were in student attitudes toward learning mathematics and the classroom environment. She said that these outcomes were much more significant to her than raising the achievement scores. She said that she was impressed that the

children could work together in groups and have fun learning mathematics. She attributed this to her SMILE training. During the following year, all of the teachers at Daniel Elementary School took part in the SMILE inservice program.

Throughout the interviews with the students and teachers, there seemed to be one overall theme. In the words of Tanya Robinette, "I think the most significant changes were in students' attitudes toward learning mathematics and changes in the classroom environment."

All of the teachers whom were interviewed were impressed by the fact that the children could work together in groups and had fun learning mathematics. This, to them, was more important than academic achievement. They stated that now, because the children could work together, they were ready to learn mathematics. This statement is supported by a study that found a direct association between positive student attitudes and improved classroom environments. Students typically achieve more when there is a positive classroom environment (Fraser, 1994).

SUMMARY, DISCUSSION AND CONCLUSION

The purpose of our research was to investigate if implementing Project SMILE positively influenced the classroom environment and student attitudes. Based on a sample of 120 elementary school students in Florida, the classroom environment scales of Satisfaction, Friction, Competitiveness, Difficulty and Cohesiveness (based on the My Class Inventory, MCI) and attitude scales (based on the 1988 NAEP Attitude Survey) displayed adequate internal consistency reliability and discriminant validity for both the pretest and posttest for the attitude questionnaire and for both the actual and preferred versions of the MCI. In addition, the actual form of the MCI differentiated significantly between the perceptions of students in different classrooms.

When pretest-posttest changes in students' attitudes were analyzed, statistically significant differences and appreciable effect sizes were obtained for attitudes to mathematics and reading. This finding supports the effectiveness of Project SMILE in promoting positive student attitudes.

For the purposes of evaluating the effectiveness of SMILE teachers in creating positive learning environments, we compared actual and preferred scores on the MCI. The levels of classroom Satisfaction and the Difficulty of the work that were actually created by these teachers was found to be very similar to the levels preferred by the students. Given that many studies internationally have established a pattern in which students' actual classroom environment falls short of their preferred environment (Fraser,

1998a), the similarity of actual and preferred scores for Satisfaction and for Difficulty provides positive support for the effectiveness of SMILE.

However, relative to student preferences, the actual environment of the SMILE teachers' classrooms was perceived to have too much Friction and Competition and too little Cohesiveness. One reason for this could be the influence on classroom teaching of the high stakes testing that takes place in Grade 5 in the state of Florida. These findings suggest the desirability in revising SMILE inservice programs in ways that help teachers to create classroom environments that are more cohesive, less competitive and have less friction.

As in considerable prior research (e.g., Fraser, 1998a; McRobbie & Fraser, 1993), we explored associations between students' attitudes and their perceptions of actual classroom environment. As dependent variables, we used not only the three NAEP attitude scales for reading, writing and mathematics as dependent variables, but also the Satisfaction scales from the MCI as recommended by Majeed et al. (2003). The other four MCI scales were used as independent variables. Only student satisfaction was found to be significantly related to the student-perceived learning environment on the MCI. In particular, student satisfaction was high in cohesive classrooms.

Collecting qualitative data involved observing classrooms, interviewing teachers and students on a daily basis, working with students during class time, obtaining written responses to specific questions, and examining student notebooks and achievement test responses (Erickson, 1998). We also looked at the mathematics achievement of case study schools on both school-developed tests and statewide achievement tests. Feedback from the teachers on the written reports of the study was used as another data source. From the six teachers interviewed, two teachers and their students were chosen for the case studies. All data were compiled into written field notes following each lesson, observation or interview.

The qualitative information generally supported the patterns of results from the questionnaires and enhanced our understanding of how Project SMILE operated to enhance students' classroom environment and attitudes toward reading, writing and mathematics. After attending the SMILE inservice course, the teachers involved in the study began writing mathematics lessons that employed children's literature. They no longer taught mathematics in a traditional way (involving following the book page by page). They were using hands-on activity-based lessons. The teachers typically felt more secure with the mathematical content. Teachers observed that the children were happier when studying mathematics.

The children found that mathematics was no longer boring and that it was fun to do the activities. The children's literature books seemed to help the children to gain more interest and confidence in learning mathematics. They made greater academic progress on teacher-made assessment tasks. The children said: "Mathematics is fun." Overall, both the quantitative and qualitative data supported the effectiveness of Project SMILE in terms of providing the elementary (K–5) mathematics classroom with a positive classroom learning environment and with positive attitudes. Moreover, our case studies of a small number of classes (not reported in this article) provided impressive but tentative evidence about the effectiveness of SMILE in promoting students' mathematics achievement.

There is a number of limitations associated with our evaluation of Project SMILE. Because only 120 students completed all aspects of the study because of student absences and student transfers, our relatively small sample size could present a limitation to this study. Compared to the general population of Grade 5 students in the county, the sample used was neither sizeable nor representative of the full range of elementary schools and students. Therefore, it is unclear if our findings would apply to the full range of Grade 5 students. Also the power of the statistical analyses was limited by the sample size in some cases.

The second limitation of our study is that, because some of the children in the sample are language-deficient, it is possible that they misinterpreted some of the questionnaire items (despite the fact that the MCI has a very low reading level).

A third limitation is that we did not administer the MCI on two occasions to gauge changes in classroom environment over time. Results from a pretest of the MCI would have been helpful when trying to assess the impact of SMILE on changes in the classroom environment. Nevertheless, we still were able to compare actual and preferred learning environments after the implementation of SMILE as a way of furnishing evidence to inform our evaluation of SMILE.

Another limitation related to the MCI is the fact that it is a somewhat outdated questionnaire. Therefore it does not capture all the dimensions of contemporary relevance that are assessed by contemporary instruments that are reviewed by Fraser (1998b). However, our choice of the MCI can be justified partly in terms of the suitability of its low reading level for our population of poor readers.

The fact that the scope of our study did not encompass a thorough investigation of the impact of Project SMILE on students' mathematics achievement gives rise to another limitation. Nevertheless, our qualitative

case studies provided some interesting preliminary evidence of the positive impact of SMILE on students' mathematics achievement.

A final limitation was the fact that the SMILE inservice program was not the only inservice workshop in which some of the teachers were enrolled. Unfortunately, some teachers enrolled in more than one inservice program at a time. Therefore, the attitudes of the students and classroom environment might have been influenced by teachers' experiences in other workshops. However, the qualitative data helped to corroborate the fact that the teachers learned the strategies from the SMILE inservice program and that the positive attitudes and learning environments were subsequently fostered in these teachers' elementary school classrooms.

Our research makes distinctive contributions to the field of learning environments. It represents one of the relatively few studies that have employed learning environment dimensions as criteria of effectiveness in the evaluation of educational innovations (Maor & Fraser, 1996; Nix et al., 2004). It also is one of relatively few studies in the field of learning environments that has focused on elementary (K–5) school mathematics.

Our study suggests at least three future directions: extending of the research to include other classroom environment questionnaires and student achievement; extending of the research to include a larger and broader sample; and replicating the evaluation of Project SMILE in other geographic areas throughout the USA and other countries.

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